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Plasma Processing Power for Nanocarbon Nanobioelectronics

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It is demonstrated that nanoscopic processing in gas-phase, liquid-phase, and gas-liquid interfacial plasmas is effective in pioneering next-generation nanoelectronics and nanobio-fusion science. Actual materials to be targeted here for plasma-mediate functionalization are a nanocarbon family consisting of fullerenes, carbon nanotubes (CNTs), metal nanoparticles (MNPs), and biomolecules such as DNA. In the case of gas-phase plasmas, the mass synthesis of charge- and/or spin-exploited atom encapsulated (@) fullerenes is realized (Li@C_{60}, N@C_{60}) and under investigation (Ni@C_{60}) toward nano-biomedical applications. The structure controlled growth of high quality single-walled carbon nanotubes (SWNTs) with a narrow chirality distribution is also realized using the diffusion plasma-CVD method. Inner nanospaces of CNTs are controlled with the plasma-ion irradiation method, enabling various kinds of atoms and molecules @CNTs to display novel electrical, optical, and magnetic nanodevice-characteristics. In the liquid-phase case, single- and double-stranded DNA@CNTs are created by applying DC and RF electric fields in micro electrolyte plasmas. Versatile control of CNT semiconducting properties is achieved depending on each kind of encapsulated DNA bases such as cytosine and guanine. Photoinduced electron transport phenomena are also observed upon SWNT-DNA conjugates under the FET configuration, being applicable to photoswitching nanobio devices. Finally, gas-liquid interfacial plasmas are stably generated using a kind of fully-ionized liquid plasma, ionic liquids (ILs), in contact with gas discharge areas. Gas-phase plasma irradiation to the IL through electrostatic potential differences at the interface leads to the synthesis of MNPs and MNP-CNT conjugate. Then, based on the successive synthesis of MNP-DNA conjugate, (MNP-DNA)@CNTs are challenged to be created by superimposing pulse DC electric fields upon DC fields in the solid-liquid-gas interfacial regions. The results are expected to be available for developing innovative nanomedicine.